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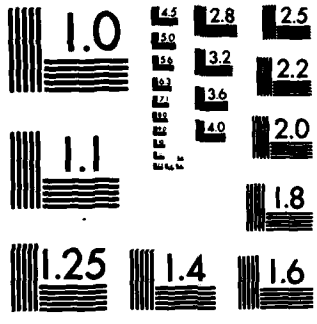

RESEARCH IN MONOLITHIC, SIGNAL-PROCESSING CIRCUITS

FINAL REPORT

R. G. Meyer and D. O. Pederson

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College of Engineering
University of California, Berkeley
94720

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Research results in monolithic signal processing circuits are described. New topologies were devised for low-noise monolithic voltage-controlled oscillators leading to measured performance eighty times better than previously reported. A new theory describing start-up and steady state in monolithic crystal oscillators was devised and used to realize a one-pin crystal oscillator. A new all-MOS analog multiplier was synthesized, fabricated, and measured to have performance comparable to more mature bipolar versions, while consuming much less silicon area.

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RESEARCH RESULTS

Research supported under this grant led to significant results in several areas.

A major research project under this program has been the synthesis of new low-noise monolithic voltage-controlled oscillator (VCO) topologies. Theoretical analyses allowed prediction of relaxation oscillator noise performance for the first time and these techniques were used to create a new VCO with measured phase jitter less than 1ppm. The previous best reported performance was 80 ppm. Our theoretical analyses showed the need for special low-noise pre-amplifiers separating the regenerative elements from the charge-storage elements. Measurements on prototype circuits confirmed the theory as did injection of external noise sources to verify the insensitivity of the new topology to internal noise sources in the regenerative circuit. Oscillators with such low noise characteristics find wide application in many communication systems such as phase-locked loops and FM modulators and demodulators.

A second major research effort was development of a theory describing start-up and steady-state conditions in monolithic crystal oscillators. Initial work was directed towards Pierce topologies and resulted in the development of a theory allowing design of monolithic crystal oscillators for prescribed steady-state signal and bias conditions. This was extended to include criteria for reliable start-up which had been observed to be a major problem in many commercial on-chip block oscillators. Experimental work involved both MOS and bipolar realizations.

In the past, all reliable monolithic crystal oscillators have required two package pins (plus access to the power supply) for their

implementation. However, with the growing number of circuit functions being included on-chip, great pressure has developed to conserve pin connections in order to allow maximum input-output interfacing in the confines of a fixed package. Thus the attraction of a so-called "1-pin" crystal oscillator is very great and we investigated methods of realizing such a circuit. Building on our earlier work, we derived a design procedure for the synthesis of 1-pin monolithic crystal oscillators with well-defined amplitude and start-up. Several monolithic versions of the 1-pin oscillator have been layed-out and fabricated and detailed measurements showed excellent agreement with theory.

A third and very important aspect of our research has been directed towards MOS signal-processing circuits. Initial work on MOS voltage-to-current converters yielded new topologies with less than 1% harmonic distortion at 95% of full-scale output. These techniques were based on careful preservation of the MOS square-law transfer function via innovative circuit and process techniques. These techniques were extended further to realize the first MOS analog multiplier with performance comparable to more mature bipolar circuits. In particular, monolithic prototype multipliers fabricated in our laboratory had measured linearity better than 0.3% at 75% of full-scale swing, a bandwidth of dc-1.5 MHz and output noise 77dB below full scale.

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Participating Personnel

R. G. Meyer	Faculty Investigator
D. O. Pederson	Faculty Investigator
M. Soyeur	Ph.D. Student
A. Abidi	Ph.D. Student (awarded Ph.D.)
D. Soo	Ph.D. Student
T. P. Lin	Ph.D. Student
J. Fattaruso	Ph.D. Student
K. Toh	Ph.D. Student
J. Santos	M.S. Student
D. Ellis	M. S. Student
M. Unkrich	M. S. Student

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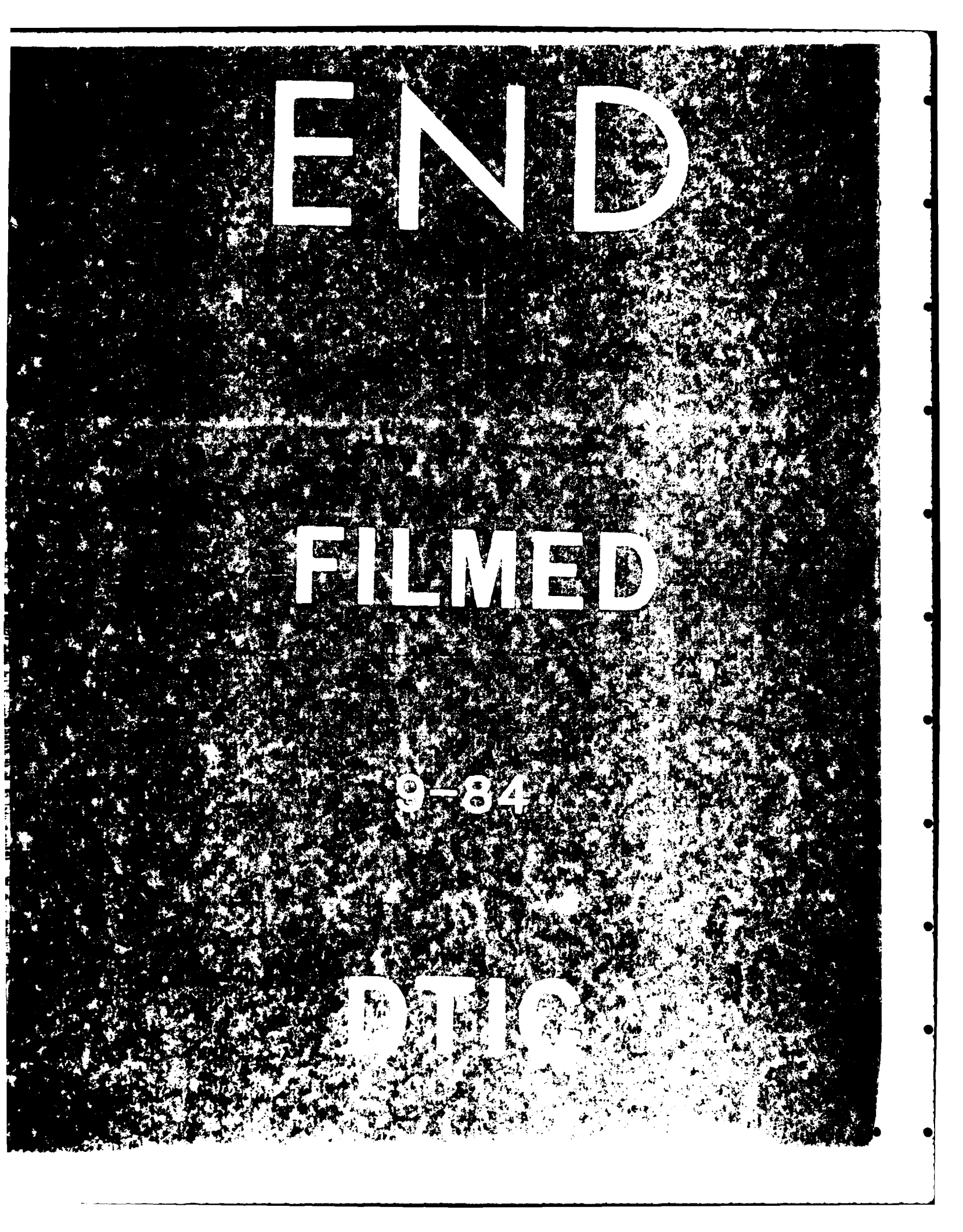
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